# Comparative Analysis of Management Alternatives for Dredged Material in New York/New Jersey Harbor

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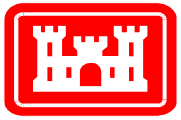
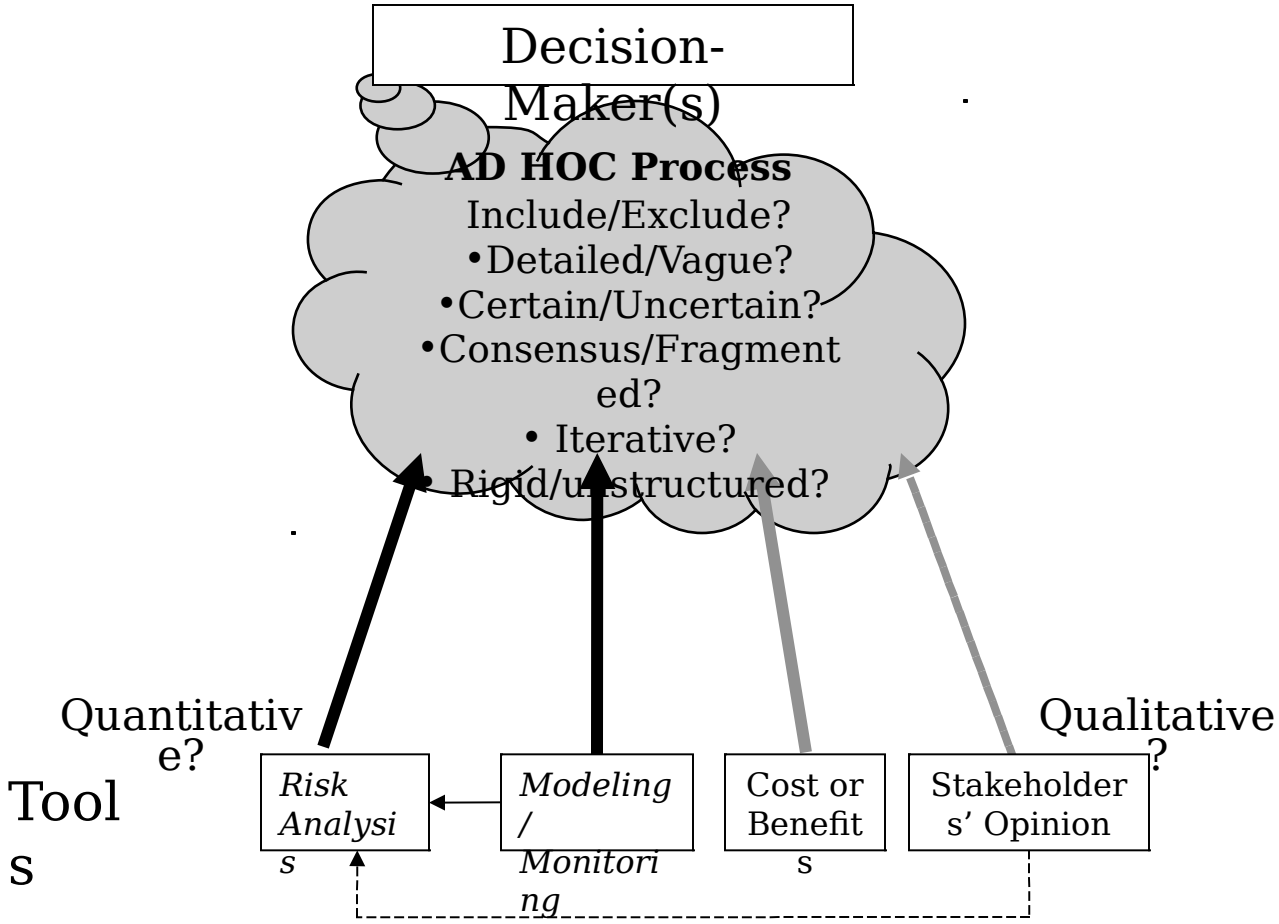


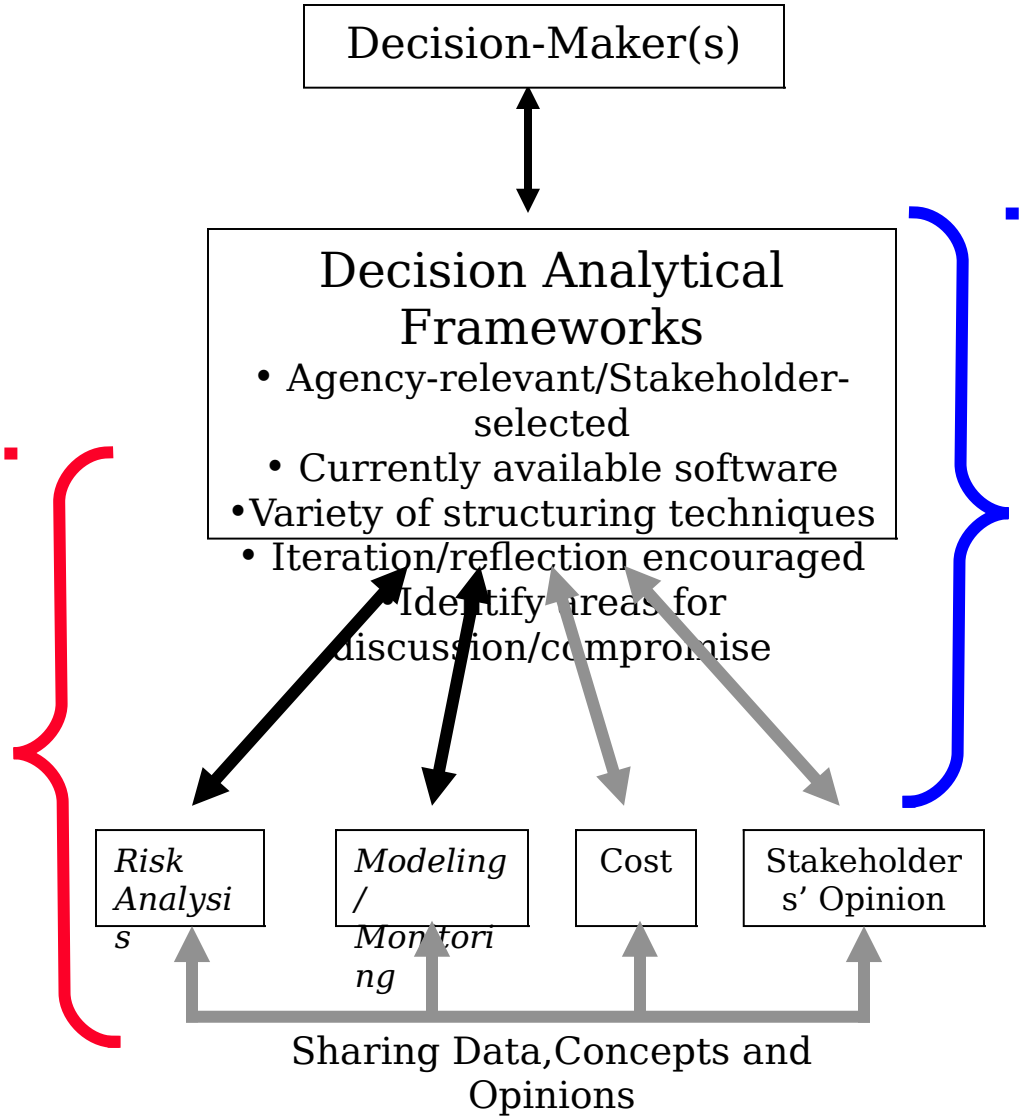
# Presentation -- Overview

- **Environmental evaluations and decisions are growing more complex**
- **Decision analysis tools provide a means of integrating various technical inputs with stakeholder values**
  - **Multi-Criteria Decision Analysis**
  - **Example with Decision Software (NY/NJ Harbor)**
- **The Way Forward…**

# Current Decision-Making Processes



# Evolving Decision-Making Processes

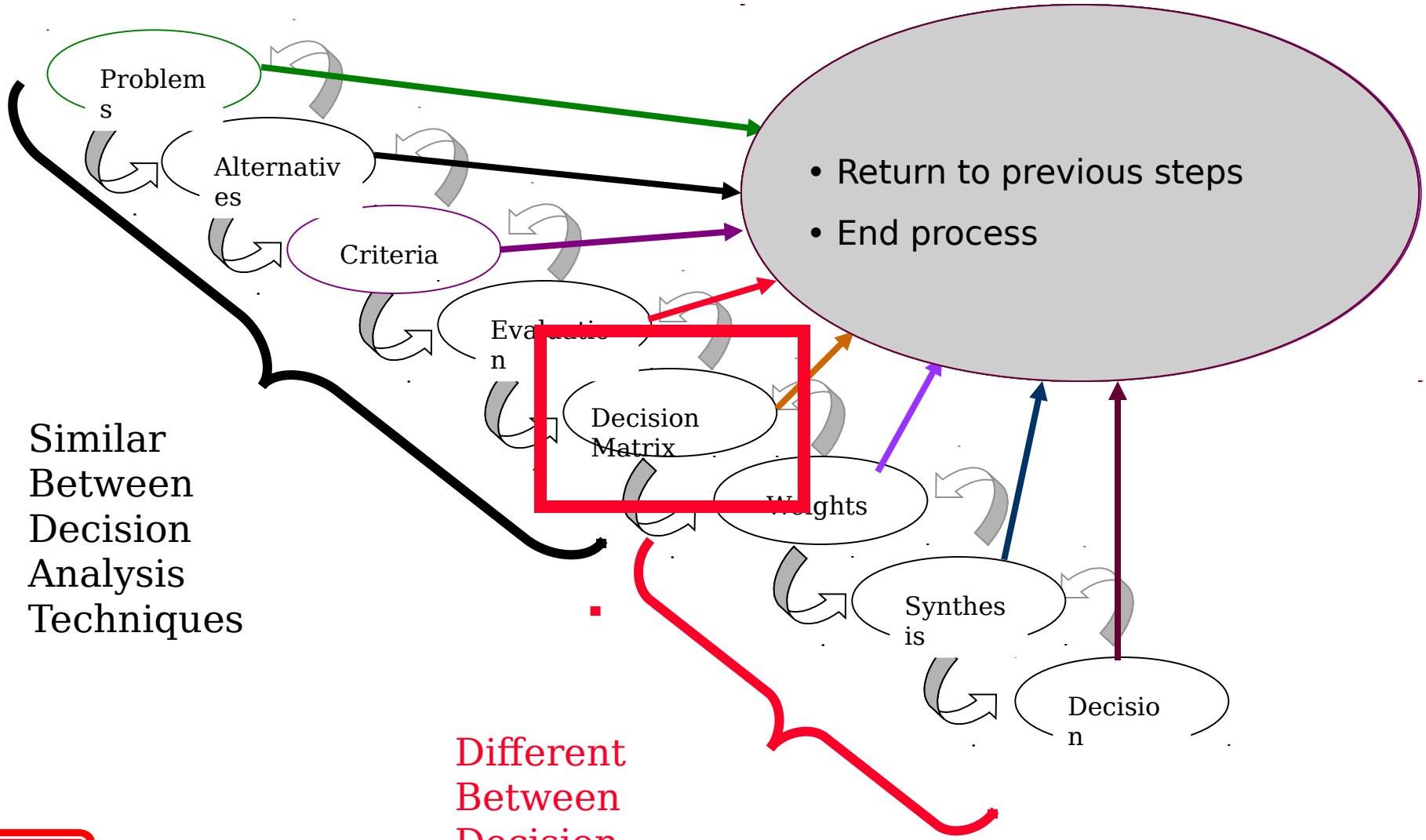



**Tool Integration**

**Decision Integration (MCDA)**

# Multi-Criteria Decision Analysis

***(Yoe, 2002)***




Similar Between Decision Analysis Techniques

Different Between Decision Analysis Techniques

# *Current Challenge: Comparing Apples and Oranges (or Fish, Ducks and Money)*

| Plan | Cost | Fish | Ducks |
|---|---|---|---|
| A | 100 | 10 | 5 |
| B | 100 | 5 | 10 |
| C | 150 | 10 | 10 |
| D | 150 | 10 | 15 |

After Yoe (2002)

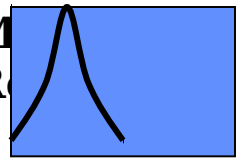
# Example Decision Matrix

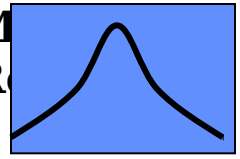
How to combine these criteria?

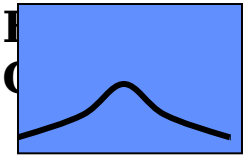
How to compare these alternatives?

How to compare these results?

| | Criteria 1 | Criteria 2 | Criteria 3 | Criteria 4 |
|---|---|---|---|---|
| Alt. | ] Result | Preference | Cost | monetary benefit |
| Alt. | Model X Result | Stakeholder Preference | Economic Cost | Non-monetary benefit |
| Alt. | M R | Stakeholder Preference | Economic Cost | Non-monetary benefit |
| Alt. | M R | Stakeholder Preference | I C | Non-monetary benefit |





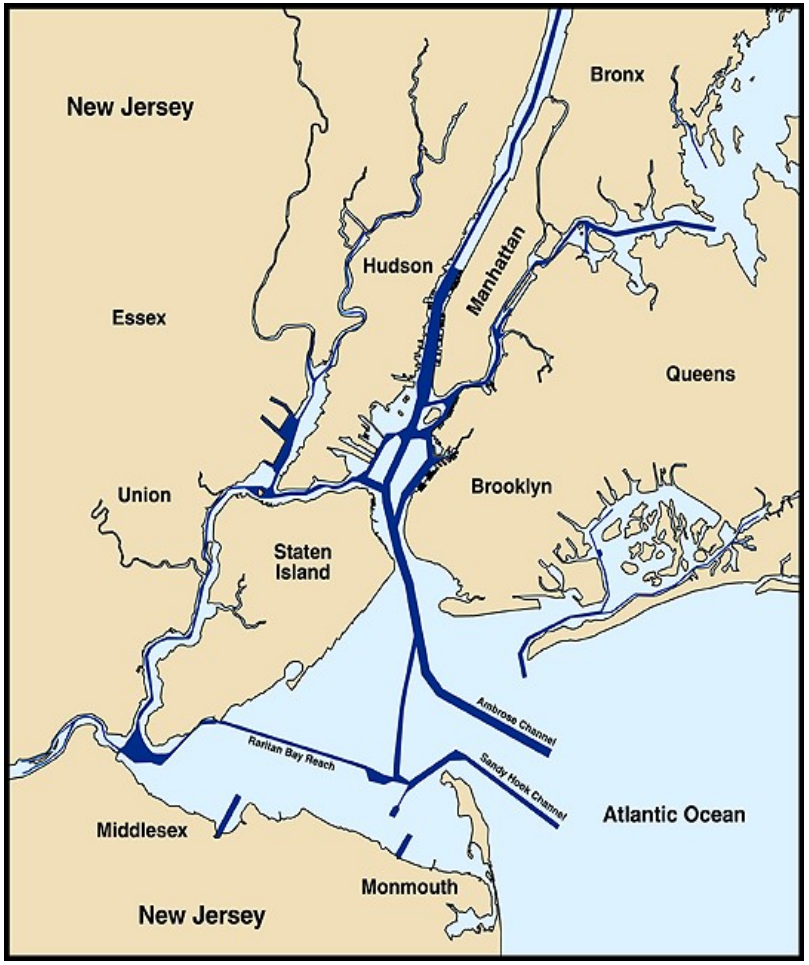


# Case Study: NY/NJ Harbor

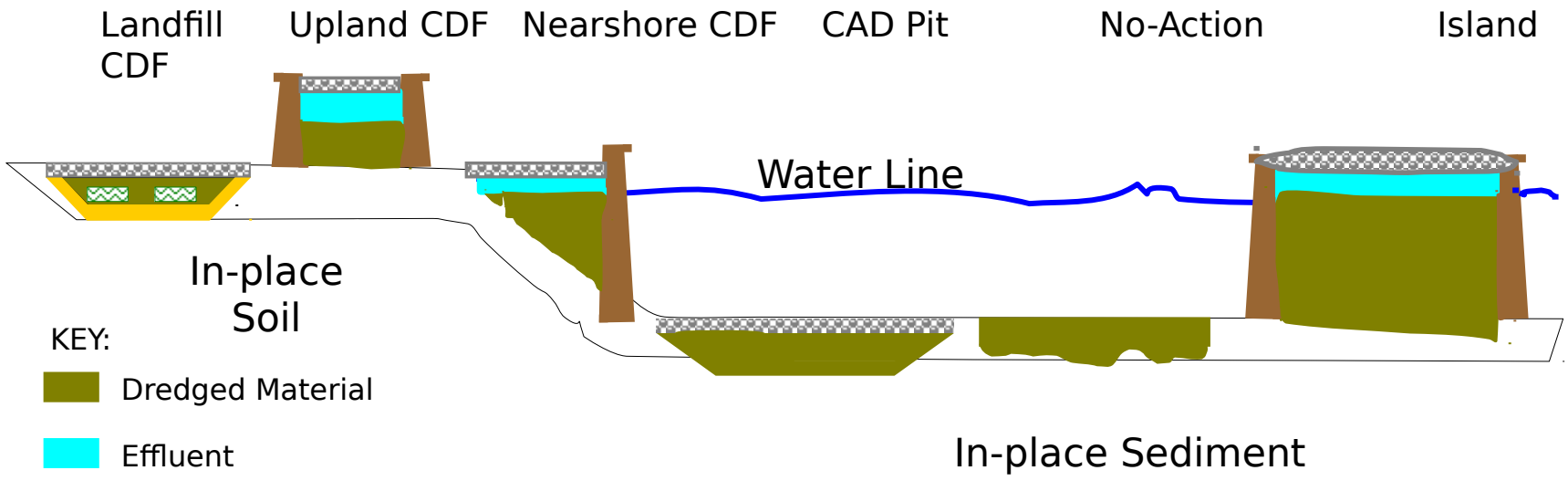
# *Case Study: NY/NJ Harbor*

Issues

- **Harbor among most polluted in U.S.**
- **>$10^6$ $yd^3$ fail regional criteria for ocean disposal**
- **Existing disposal site closed 1 Sep. 97**
- **Proposed deepening**



# Conceptual Illustration of Disposal Alternatives




**Kane Driscoll, S.B., W.T. Wickwire, J.J. Cura, D.J. Vorhees, C.L. Butler, D.W. Moore, T.S. Bridges. 2002. A comparative screening-level ecological and human health risk assessment for dredged material management alternatives in New York/New Jersey Harbor. *International Journal of Human and Ecological Risk Assessment* 8: 603-626.**

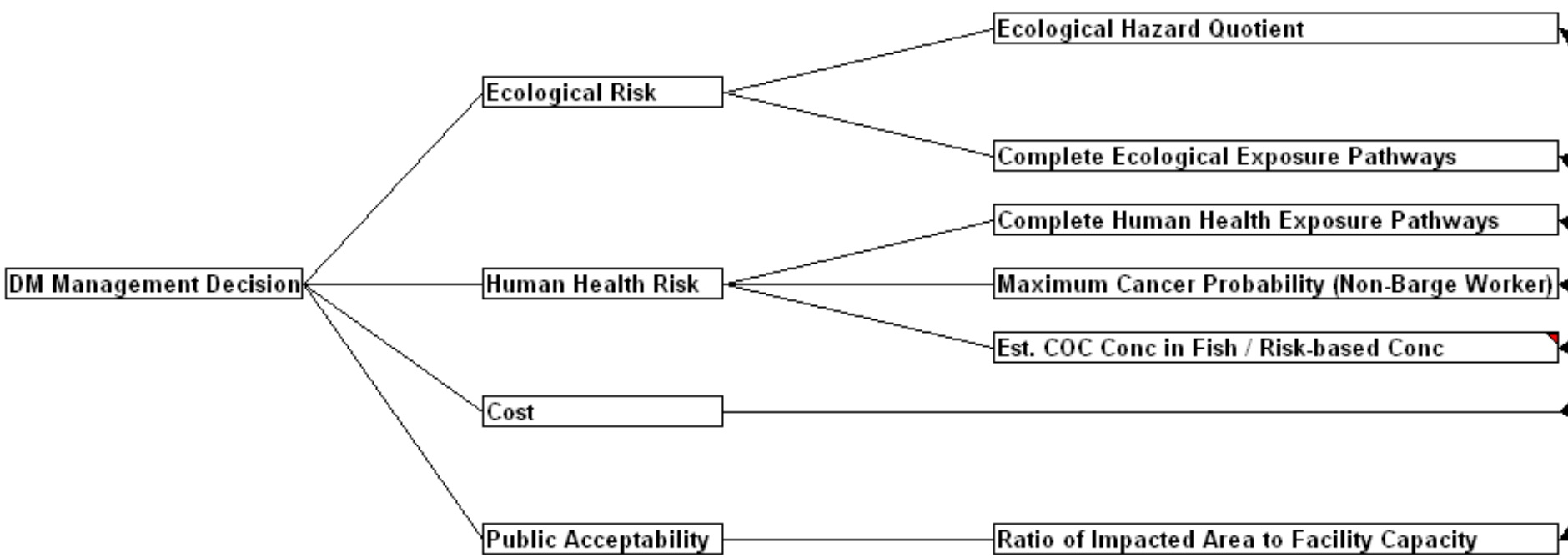
# Decision Criteria: NY/NJ Harbor

- **Ecological Risk** (Driscoll et al., 2002)
  - Number of complete ecological exposure pathways
  - Magnitude of ecological hazard quotient – maximum exposure
- **Human Health Risk** (Driscoll et al., 2002)
  - Number of complete human health exposure pathways
  - Magnitude of maximum cancer probability (non-barge worker)
  - Ratio of estimate concentration of COCs in fish to risk-based concentration
- **Cost** (NY/NJ DMMP, 1999 and Expert Opinion)
- **Public Acceptability** (Driscoll et al., 2002)
  - Impacted area/capacity of facility

# Criteria Levels for Each DM Alternative

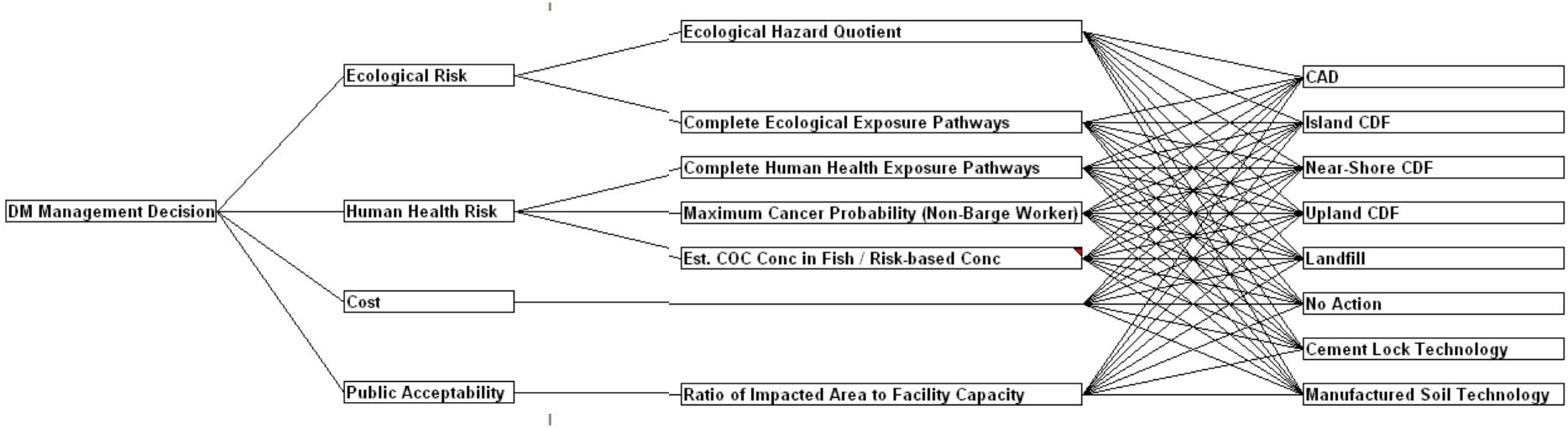
| DM Alternatives | Cost ($/CY) | Public Acceptability: Impacted Area/Capacity (acres / MCY) | Ecological Risk: Ecological Exposure Pathways | Ecological Risk: Magnitude of Ecological HQ | Human Health Risk: Human Exposure Pathways | Human Health Risk: Magnitude of Maximum Cancer Risk | Human Health Risk: Estimated Fish COC / Risk Level |
|---|---|---|---|---|---|---|---|
| **CAD** | 5-29 | 4400 | 23 | 680 | 18 | 2.8 E -5 | 28 |
| **Island CDF** | 25-35 | 980 | 38 | 2100 | 24 | 9.2 E -5 | 92 |
| **Near-shore CDF** | 15-25 | **6500** | 38 | 900 | 24 | 3.8 E -5 | 38 |
| **Upland CDF** | 20-25 | **6500** | 38 | 900 | 24 | 3.8 E -5 | 38 |
| **Landfill** | 29-70 | 0 | 0 | 0 | 21 | 3.2 E –4 | 0 |
| **No Action** | **0-5** | 0 | **41** | **5200** | 12 | 2.2 E –4 | **220** |
| **Cement-Lock** | **54-75** | 0 | 14 | 0.00002 | **25** | 2.0 E -5 | 0 |
| **Manufactured Soil** | 54-60 | 750 | 18 | 8.7 | 22 | **1.0 E –3** | 0 |

# NY/NJ Harbor in Criterium DecisionPlus



# NY/NJ Harbor in Criterium DecisionPlus

Goal Criteria Sub-Criteria Alternatives




Hierarchy Rating Technique: **Weights (Survey of USACE/EPA Dredge Material Experts)**

Alternatives Rating Technique: **SMART with linear value functions**

# NY/NJ Harbor, "Non-binding" Swing Weighting Form

| Attribute Swung from Worst to best | Consequence to compare | Rank (1-9) | Rate (0-100) |
|---|---|---|---|
| Benchmark: Worst case on everything | Impacted Area/Capacity of Facility = 6500 (acres/ $10^6$ cubic yards)<br>Magnitude of Ecological Hazard Quotient – Maximum Exposure = 5200<br>Number of Complete Ecological Exposure Pathways = 41<br>Number of Complete Human Exposure Pathways = 25<br>Magnitude of Maximum Cancer Probability (Non-barge worker) = 1* $10^{-3}$<br>Ratio of Estimated Concentration of COCs in Fish to Risk-Based Concentrations = 220<br>Cost = 54-75 $/CY | 9 | 0 |
| Impacted Area/Capacity of Facility | Change from 6500 (acres/ $10^6$ cubic yards) to 0 (acres/ $10^6$ cubic yards) | | |
| Magnitude of Ecological Hazard Quotient –Maximum Exposure | Change from 5200 to 0 | | |
| Number of Complete Ecological Exposure Pathways | Change from 41 to 0 | | |
| Number of Complete Human Exposure Pathways | Change from 25 to 12 | | |
| Magnitude of Maximum Cancer Probability (Non-barge worker) | Change from 1* $10^{-3}$ to 0.028 * $10^{-3}$ | | |
| Ratio of Estimated Concentration of COCs in Fish to Risk-Based Concentrations | Change from 220 to 0 | | |
| Cost | Change from (54-75 $/CY) to (0-5 $/CY) | | |

# *Weightings summary*

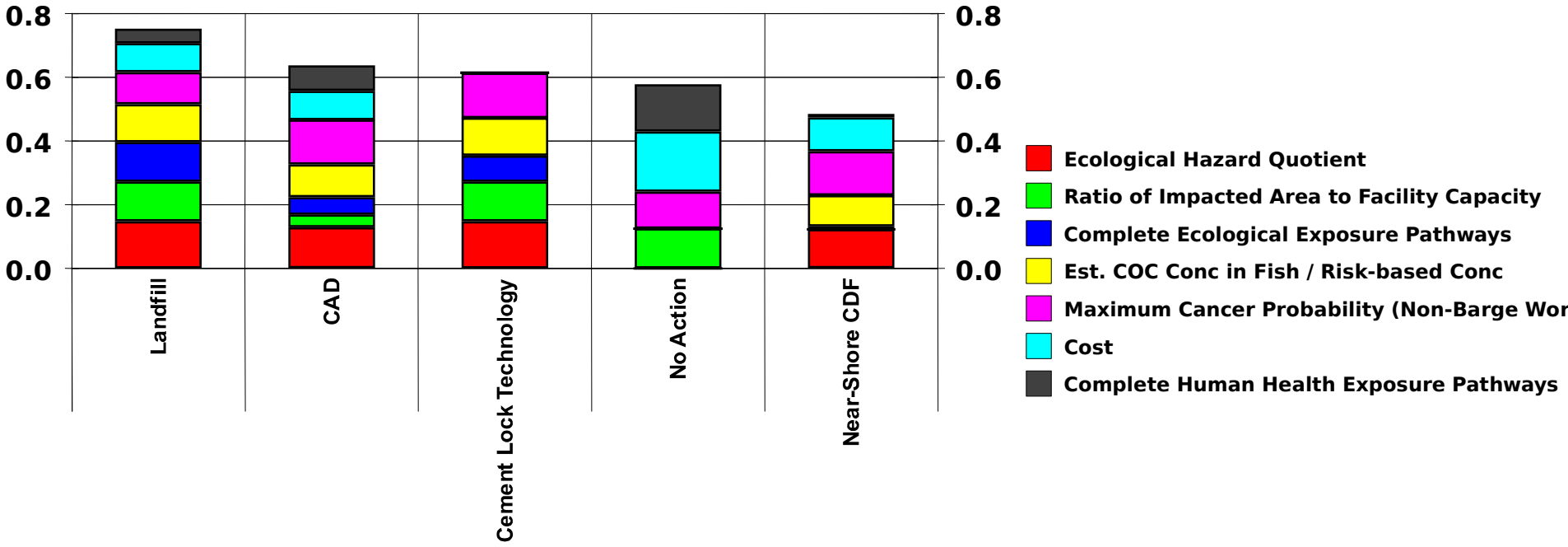
| | EPA | USACE |
|---|---|---|
| **Public Acceptability** | **7.37** | **12.46** |
| **Ecological Health** | **35.66** | **27.13** |
| **Human Health** | **47.01** | **40.76** |
| **Cost** | **9.97** | **19.66** |

# Mean Criteria Weights (with Std Dev)

| | EPA | USACE |
|---|---|---|
| Impacted Area/Capacity | 7.37 (4.87) | 12.46 (7.50) |
| Magnitude of Ecol HQ | 20.29 (6.50) | 14.72 (6.66) |
| Ecological Pathways | 15.36 (5.52) | 12.40 (4.78) |
| Human Pathways | 12.81 (5.51) | 14.79 (5.54) |
| Magnitude of Cancer Prob | 18.86 (4.53) | 14.13 (7.86) |
| Ratio of Fish COC/Risk level | 15.33 (3.89) | 11.82 (6.19) |
| Cost | 9.97 (4.15) | 19.66 (7.38) |

# Criteria Contributions to Decision Score

USACE weights, DMMP Cost estimates



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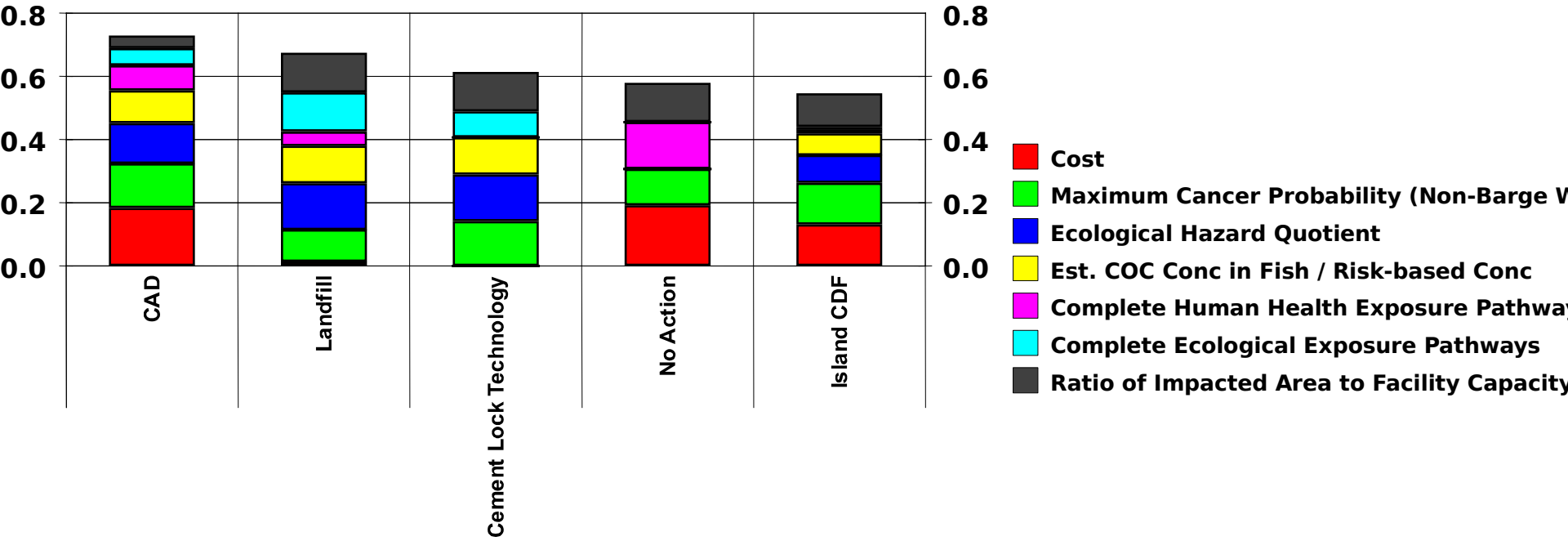
USACE weights, Expert Cost estimates



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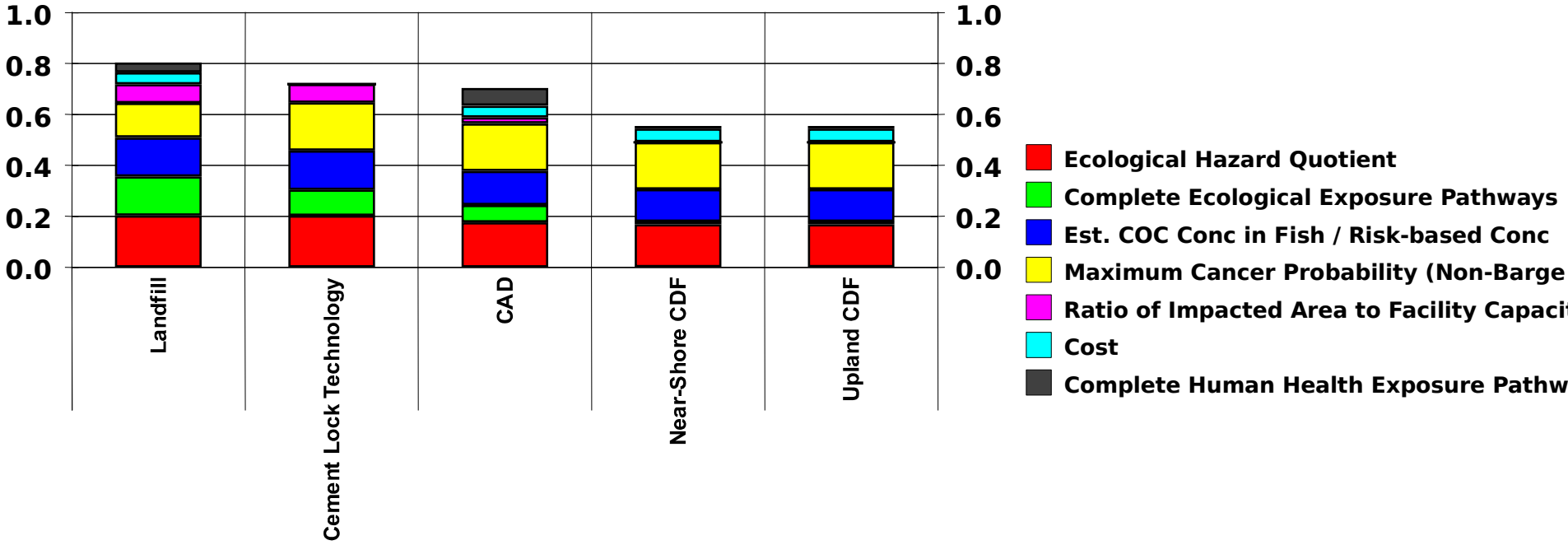

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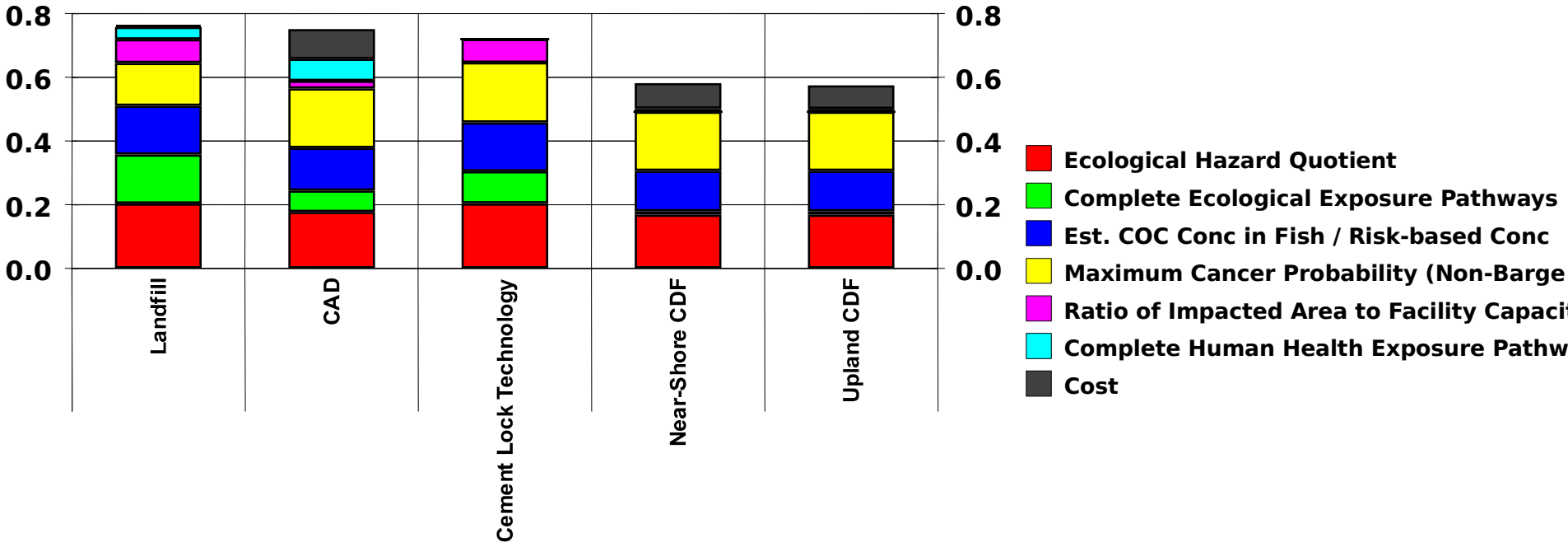


# NY/NJ Harbor Results

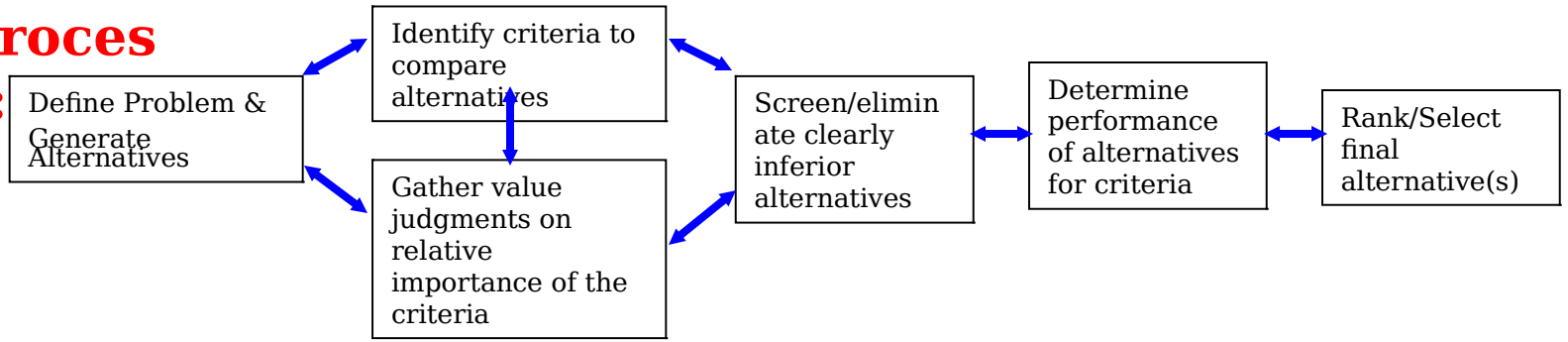
- **Though "academic", this exercise shows the value of linking comparative risk assessments and multi-criteria decision analysis**
- **The top three choices do not change much**
  - **Landfill, CAD, Cement Lock Technology**
  - **"No Action" is removed by EPA weightings**
- **Highest ranking is sensitive to matrix values and weighting**
  - **Cost criteria is particularly sensitive in USACE weightings**
  - **USACE: Landfill vs CAD**
  - **EPA: Landfill vs Cement Lock vs CAD**
- **Exercise shows both areas of compromise and potential tradeoffs**
- **Available and affordable decision analysis software helps to iterate quickly and clearly**

# Essential Decision Ingredients

## People

- Policy Decision Maker(s)
- Scientists and Engineers
- Stakeholders (Public, Business, Interest groups)

## Process:


Define Problem & Generate Alternatives
Identify criteria to compare alternatives
Gather value judgments on relative importance of the criteria
Screen/eliminate clearly inferior alternatives
Determine performance of alternatives for criteria
Rank/Select final alternative(s)

## Tools:

- Environmental Assessment/Modeling (Risk/Ecological/Environmental Assessment and Simulation Models)
- Decision Analysis (Group Decision Making Techniques/Decision Methodologies and Software)

# QUESTIONS ?